

THE PYROLYSIS BIOREFINERY CONCEPT FOR THE PRODUCTION OF GREEN FUELS AND CHEMICALS

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BIOENERGY

CRITICAL COMPONENT OF ALTERNATIVE ENERGY SOLUTION

HAS THE POTENTIAL TO ADDRESS A NUMBER OF IMPORTANT ISSUES INCLUDING:

- GREENHOUSE GAS REDUCTION**
- RURAL DEVELOPMENT**
- SECURITY/DIVERSITY OF ENERGY SUPPLY**
- URBAN AIR QUALITY**
- WASTE UTILIZATION**

BIOMASS POTENTIAL

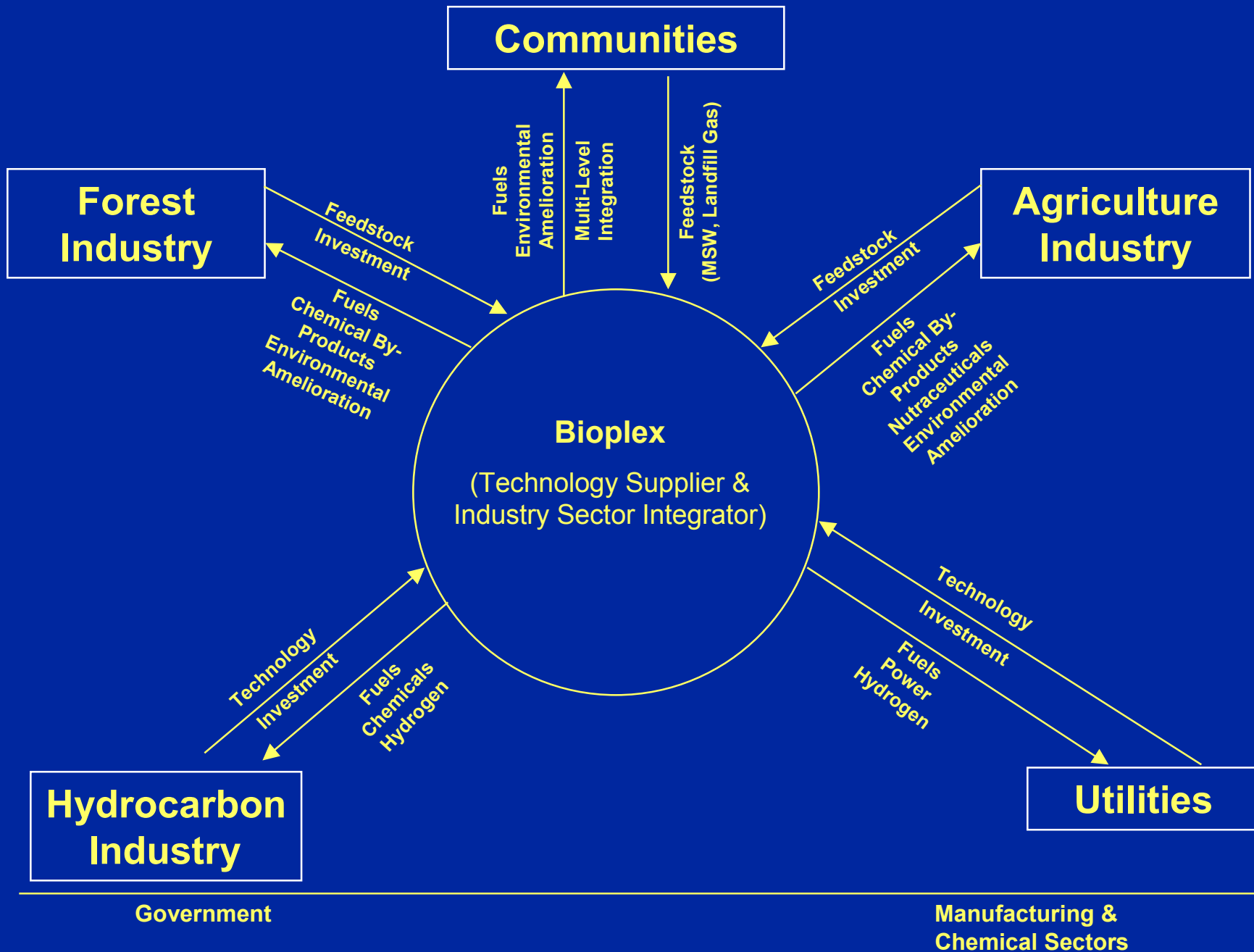
- ♦ POSITIVE IMPACT ON FOREST AND AGRICULTURAL SECTORS
- ♦ ABILITY TO PROVIDE HEAT, POWER, CHEMICALS, SPECIALTY MATERIALS AND OTHER HIGH VALUE PRODUCTS
- ♦ ENVIRONMENTAL BENEFITS – GHG, SMOG, LOW SULPHUR, SUSTAINABILITY
- ♦ “CARBON ECONOMY” – CELLULOSE IS SECOND MOST ABUNDANT CARBON SOURCE IN THE WORLD
- ♦ COMPATIBLE WITH FOSSIL FUEL & ELECTRICITY GENERATION INFRASTRUCTURES
- ♦ SECURITY AND CONTINUITY OF SUPPLY

CHALLENGES

- ♦ **CONCERNS WITH BIOMASS SUPPLY – QUANTITY AVAILABLE, QUALITY, COST, RELIABILITY**
- ♦ **LACK OF SUCCESSFUL INDUSTRIAL DEMONSTRATIONS**
- ♦ **TECHNOLOGY DEPLOYMENT ENCOMPASSES A RANGE OF MULTI-DISCIPLINARY TASKS, ACTIVITIES & MARKETS**
- ♦ **FINANCING – NEED TO MAKE MONEY FROM FACILITIES**
- ♦ **LARGER ENVIRONMENTAL FOOTPRINT / IMPACT THAN OTHER ALTERNATIVES**
- ♦ **STRONG OPPOSITION FROM OTHER INDUSTRY SECTORS**

BIOREFINERY – “BIOPLEX”

- ◆ **USE OF BIOMASS MATERIALS TO PRODUCE ENERGY, CHEMICALS AND MATERIALS AT SAME FACILITY**
- ◆ **INTEGRATED APPROACH THAT INVOLVES;**
 - **FOREST, AGRICULTURAL AND MUNICIPAL SECTORS AS PROVIDERS OF BIOMASS & INVESTMENT AND USERS OF ENERGY & CHEMICALS**
 - **HYDROCARBON INDUSTRY AND UTILITIES AS PROVIDERS OF INVESTMENT AND USERS AND DISTRIBUTORS OF ENERGY, FUELS AND CHEMICALS**
- ◆ **OTHER SECTORS WOULD PLAY SECONDARY ROLES**
 - **GOVERNMENT PROVIDES POLICY AND FISCAL SUPPORT**
 - **MANUFACTURING AND CHEMICAL SECTORS INVOLVED IN DEVELOPING NEW PRODUCTS AND MARKETS**

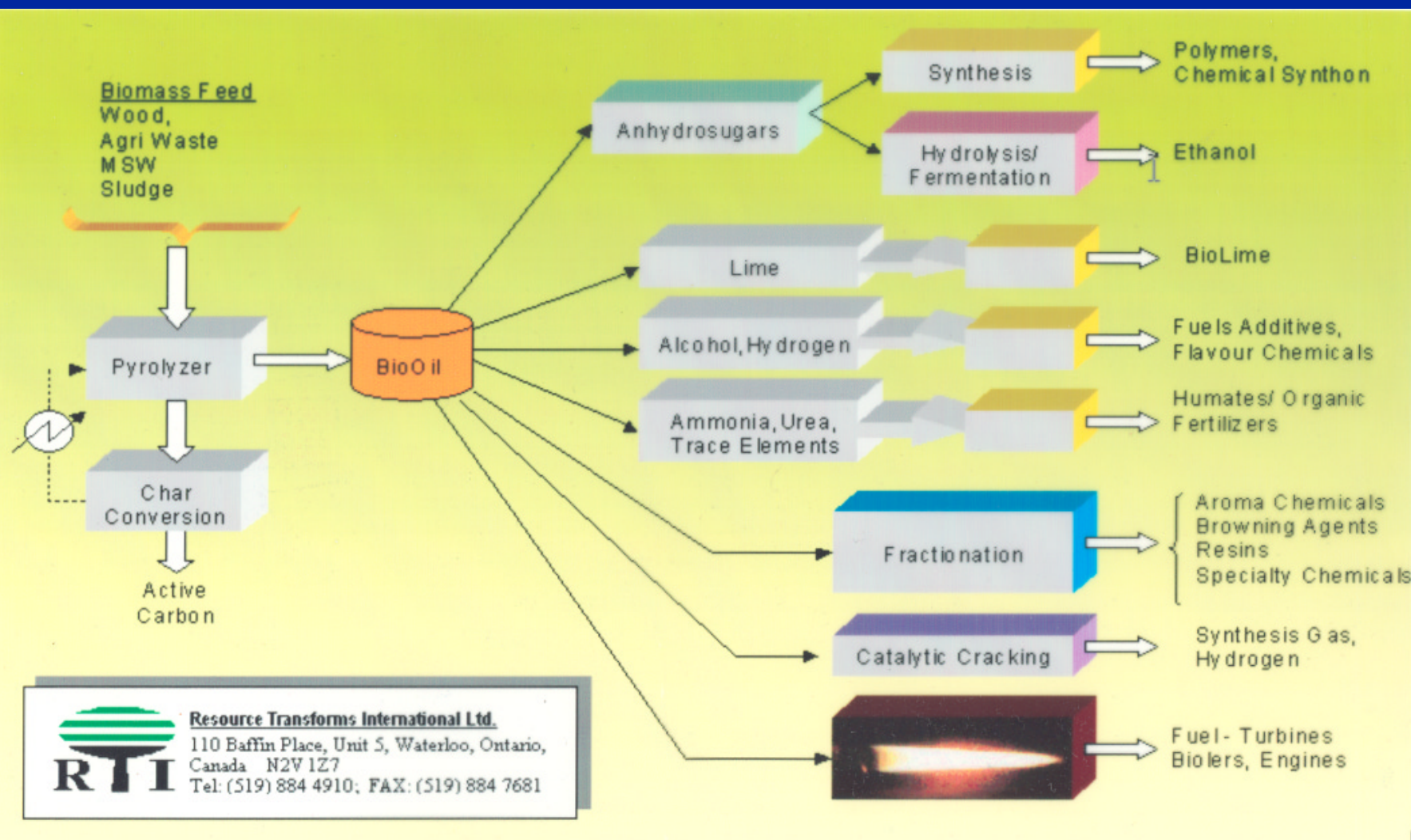


BIOREFINERY – “BIOPLEX”

- ♦ **GENERATES IMPROVED AND STABLE REVENUE STREAMS**
- ♦ **REDUCES TECHNOLOGY COSTS BY EXPANDING MARKETS**
- ♦ **EMPLOYS INNOVATIVE AND LESS POLLUTING TECHNOLOGIES**
- ♦ **GIVES INCREASED VISIBILITY AND CREDIBILITY TO THE BIOMASS INDUSTRY SECTOR**
- ♦ **PROVIDES SHARED FACILITIES & JOINT VENTURES FOR PRODUCT AND MARKET DEVELOPMENT & COST REDUCTIONS**

WHY PYROLYSIS?

- ♦ **DECOUPLES PRODUCTION FROM UTILIZATION**
- ♦ **TRANSPORTABLE, PUMPABLE & STORABLE FUEL**
- ♦ **HIGHER ENERGY DENSITY & EFFICIENCY**
- ♦ **COMPATIBLE WITH EXISTING FUEL INFRASTRUCTURE**
- ♦ **IMPROVES PROCESS FLEXIBILITY**
- ♦ **MULTIPLE PRODUCTS – “BIOPLEX”**
- ♦ **SUCCESSFUL COMMERCIAL & DEMONSTRATION PROJECTS**



ENERGY - APPLICATIONS - BOILERS

- ◆ **USED DIRECTLY IN 20 MBTU/H COMMERCIAL BOILERS FOR INDUSTRIAL PROCESS HEAT AND DRYING SINCE 1989 (US)**
- ◆ **APPROVED FOR USE IN DISTRICT HEATING UTILITY BOILERS (SWEDEN)**
- ◆ **SUCCESSFULLY CO-FIRED AT 5% INPUT WITH COAL IN A 20 MWe STOKER BOILER FOR POWER GENERATION AT MANITOWOC PUBLIC UTILITIES, WI.**
- ◆ **TEST PROGRAMS PERFORMED**
 - 2.5 MBTU/H FLAME TUNNEL - CANMET
 - 3.4 MBTU FLAME TUNNEL – MIT
 - 0.1 MBTU FURNACE – CANMET
 - 8.5 MBTU/H DANSTOKER – FORTUM (FINLAND)



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CANMET Burner Nozzle Test

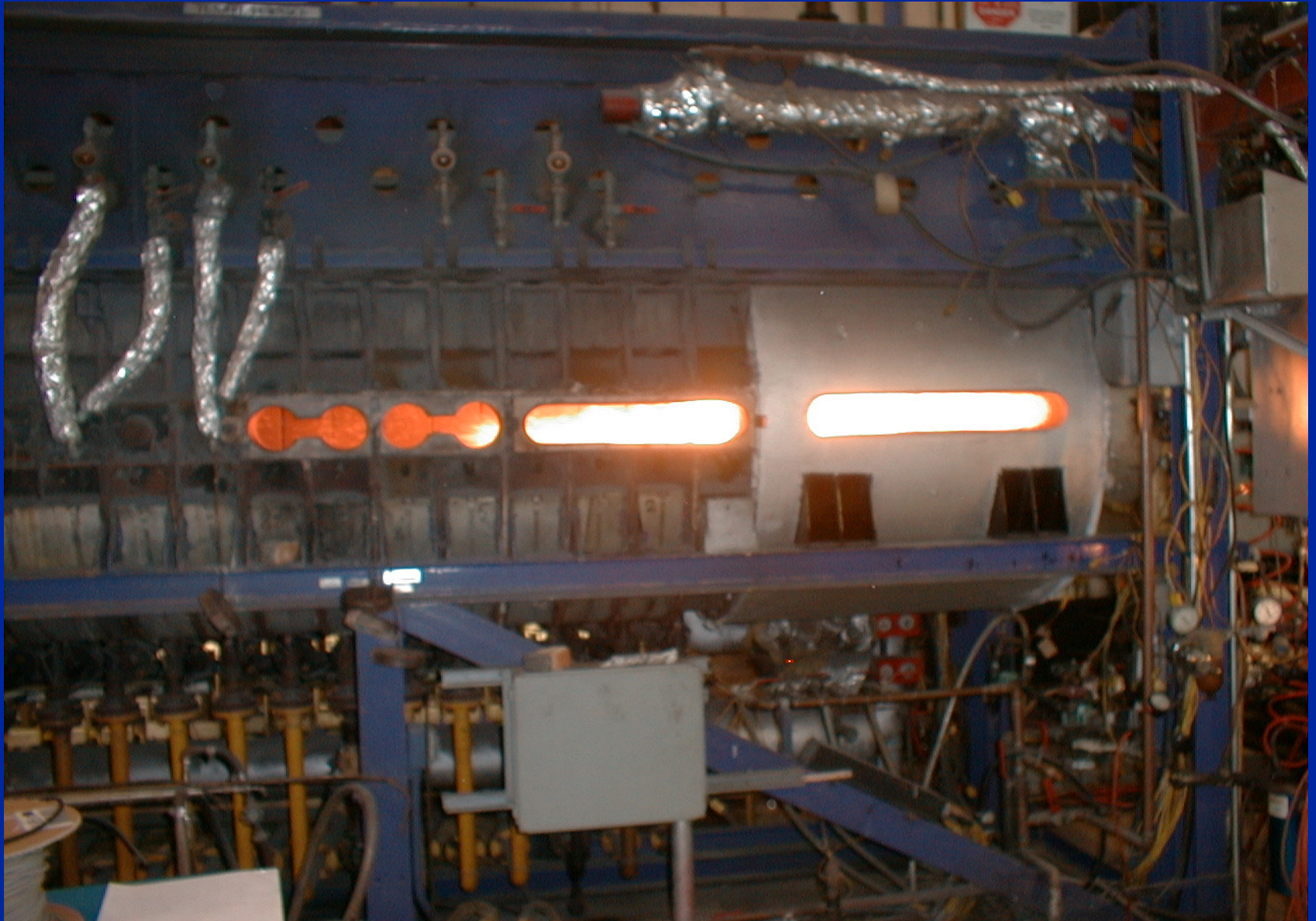




Figure 7 Location of Bio-Oil Injection in the Side of the Wicks Boiler at MPU

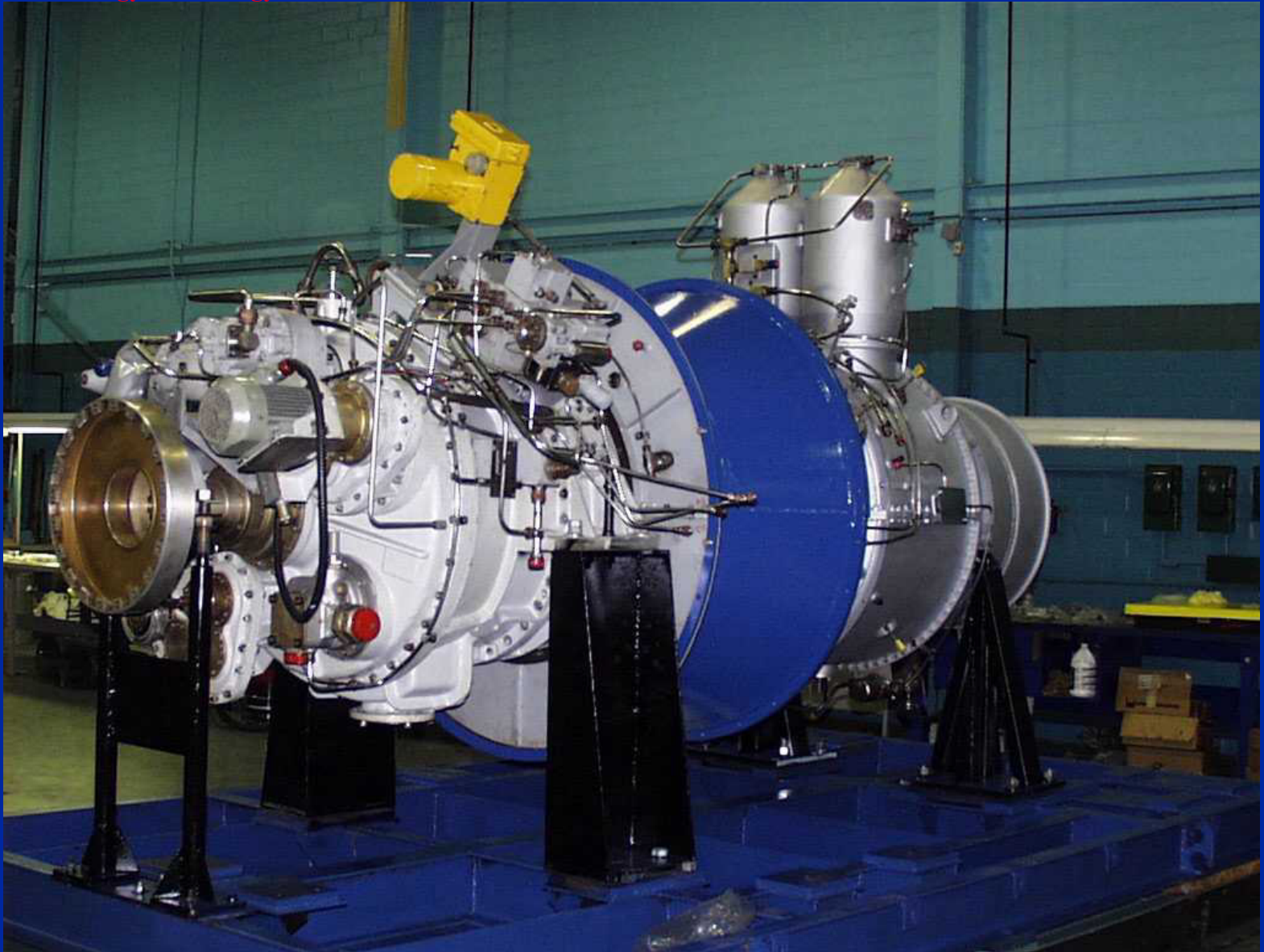
ENERGY APPLICATIONS - BEYOND

- ◆ 2.5 MWe GAS TURBINE DEVELOPED BY ORENDA AEROSPACE TO DIRECTLY FIRE BIO-OIL FOR COGENERATION APPLICATIONS
- ◆ TESTING PROGRAM UNDERWAY WITH SOLAR TURBINES (CATERPILLAR)
- ◆ MICROEMULSION PROCESS DEVELOPED TO ALLOW BIO-OIL CONVENTIONAL DIESEL TO BE MIXED WITH CONVENTIONAL DIESEL FUEL
- ◆ PRELIMINARY TESTS WITH DIESEL ENGINES – WARTSILA, MAN (EUROPE)
- ◆ VALIDATION TESTS FOR USE IN PULP MILL LIME KILNS AND SAWMILL LUMBER DRYING KILNS UNDERWAY TO REPLACE NATURAL GAS
- ◆ GASIFICATION OF PYROLYSIS OIL



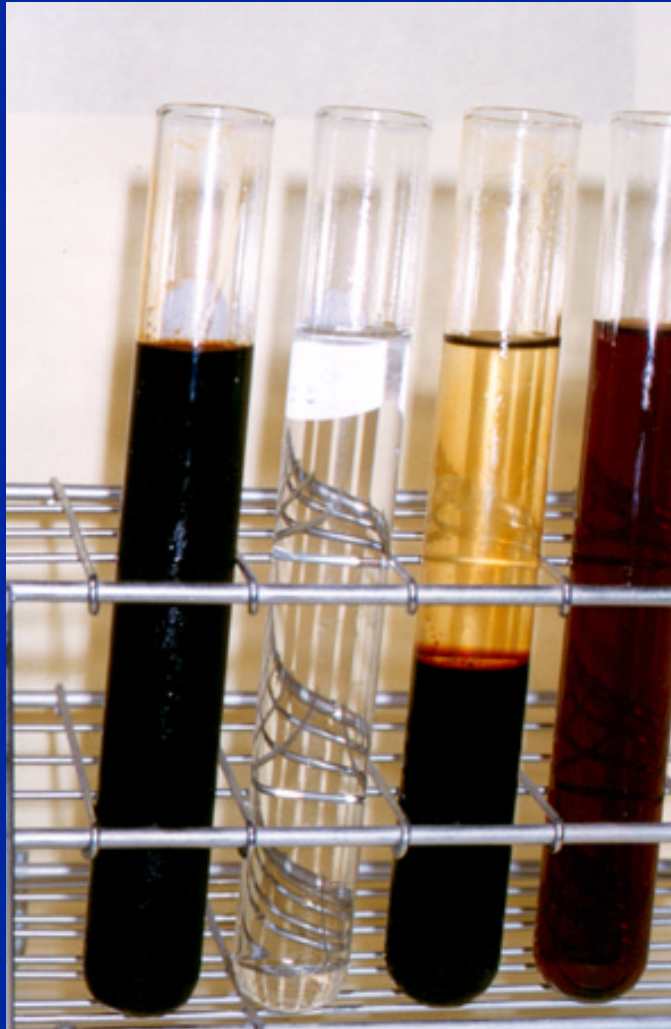
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Orenda GT2500 BioOil Fueled Turbine



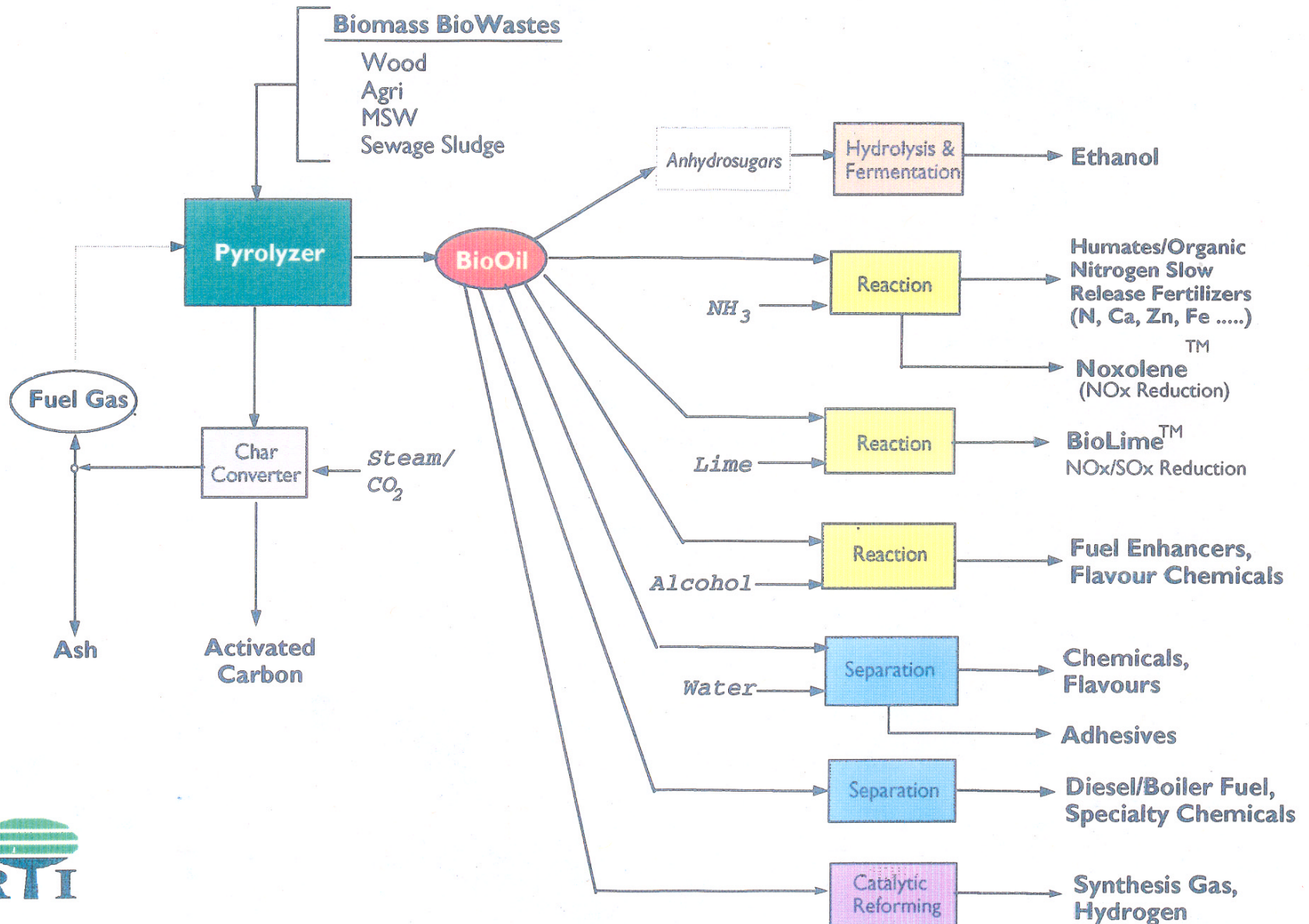
BIO-OIL DIESEL MIXTURE (BDM) FUEL

- ◆ BIO-OIL
- ◆ DIESEL FUEL
- ◆ BIO-OIL/DIESEL MIXTURE
- ◆ BDM PROCESS



BIOMASS REFINERY

CO₂ Neutral Processing



APPLICATIONS - CHEMICALS

- ◆ **RESINS & POLYMERS**
- ◆ **ACTIVATED CARBON**
- ◆ **WOOD PRESERVATIVE**
- ◆ **FOOD FLAVOURINGS**
- ◆ **SLOW RELEASE FERTILIZER**
- ◆ **NO_x / SO_x REDUCTION**
- ◆ **HYDROGEN**



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WHAT'S NEEDED

- ◆ **COLLABORATION – R & D ONWARDS**
- ◆ **GOVERNMENT RECOGNITION OF BENEFITS**
 - ENVIRONMENTAL, RURAL DEVELOPMENT
- ◆ **MARKETING / AWARENESS – GET THE WORD OUT**
- ◆ **INDUSTRIAL DEMONSTRATIONS & APPLICATIONS**
- ◆ **\$\$\$\$**